Artificial Intelligence

Chapter -15

https://xkcd.com/329/

LEARNING OBJECTIVES

- Describe the two types of artificial intelligence
- Explain the pros and cons of various knowledge representation methods
- Explain the parts of a simple neural network, how it works, and how it can incorporate machine learning

INTRODUCTION

Artificial Intelligence (AI): creating computer systems that exhibit aspects of human intelligence.

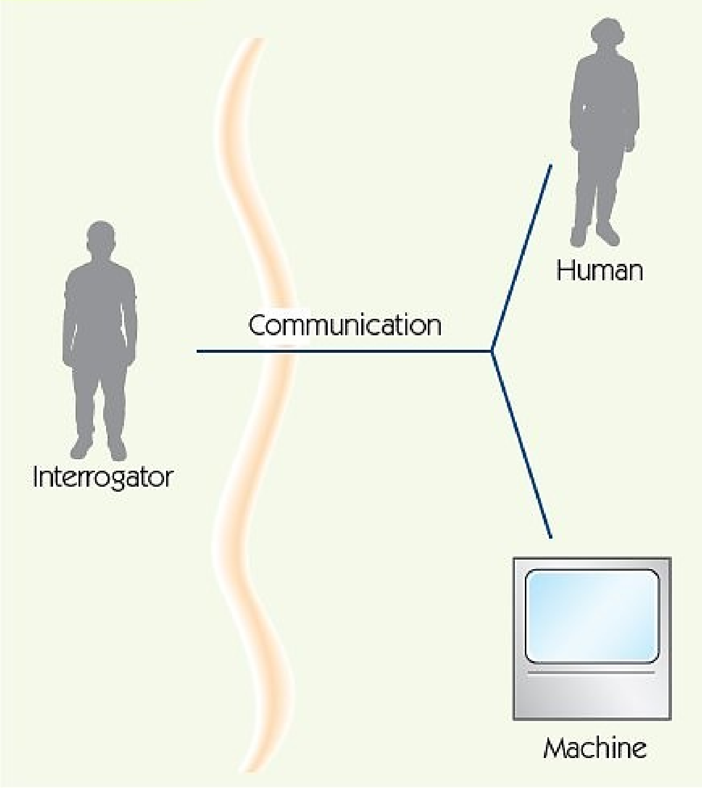
What is intelligence?

The **Turing Test** (by Alan Turing 1950)

- Human judge questions two hidden entities
  - One entity is a person
  - One entity is a computer

- If the judge cannot distinguish the computer's response from the person's more than half the time, then the computer is intelligent!

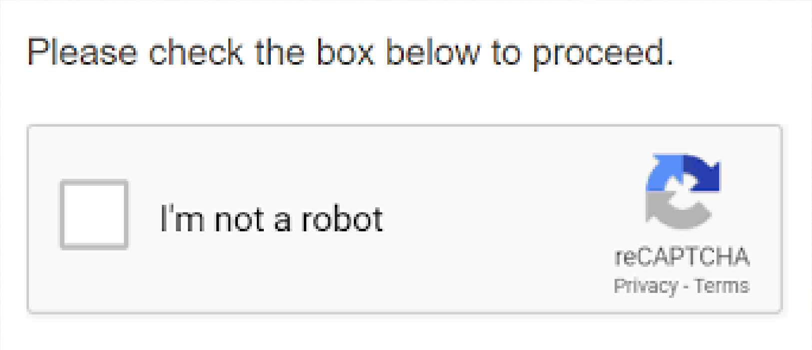
FIGURE 15.1



The Turing test

REVERSE TURING TEST

The computer administers a test to determine if the subject is human or not.



CAPTCHA - Completely Automated Public Turing Test to tell Computers and Humans Apart

PROBLEMS WITH THE TURING TEST

- One counter argument – the Chinese room argument was put forward by John Searle in 1980.

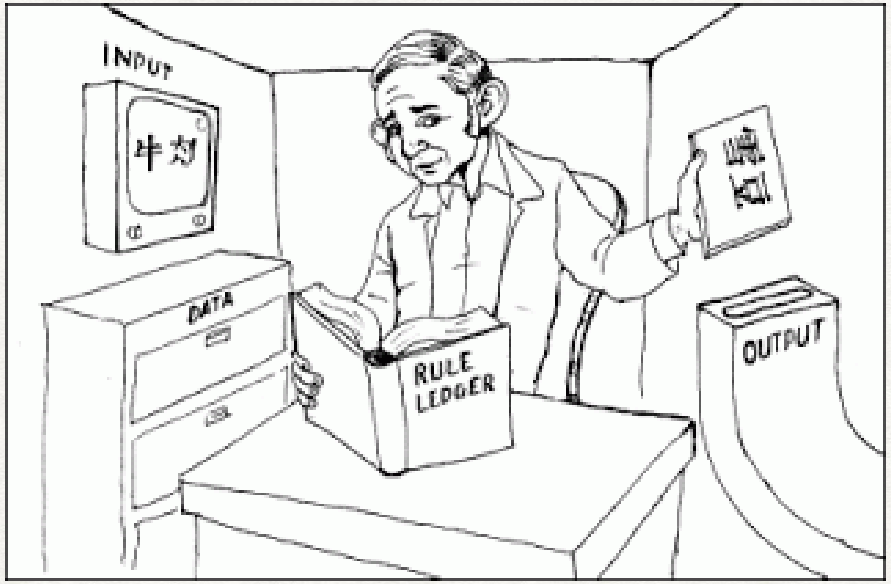


Image source:
https://theness.com/neurologicablog/index.php/ai-and-the-chinese-room-argument/

1. Get Chinese symbols as inputs.
2. Look at a rule book in native language.
3. Output a symbol based on the rules.

➢ Somebody outside the room might think that what/who is inside the room understand Chinese.

- Passing the Turing test does not mean the computer "understands" what it is doing + It is limited to the natural language skills.
- Questions the nature of intelligence and the definition of artificial intelligence.
- Topic still debated by scientists and philosophers nowadays.

https://www.ibm.com/cloud/learn/strong-ai

WINOGRAD SCHEMA CHALLENGE
(NAMED AFTER TERRY WINOGRAD)

This test proposed giving a statement to the machine that could not be interpreted properly unless the machine had the sort of experience and understanding a human being has.

A Winograd Schema Challenge consists of a statement and a question.

The statement must contain
two *entities* and
an ambiguous *pronoun*
that could, refer to either of the two entities.

The question asks which of the entities the pronoun refers to and must require some sort of *world knowledge* and *reasoning* for its resolution, (what is common sense for us).

WINOGRAD SCHEMA CHALLENGE : EXAMPLES

1. The city councilmen refused the demonstrators a permit because *they* feared violence.

   The city councilmen refused the demonstrators a permit because *they* advocated violence.

   Question to the machine: *Who does "they" refer to?*

2. Alice moved in with Berta when *she* had a spare room in her flat.
   Alice moved in with Berta when *she* had a moldy room in her flat.

   Question to the machine: *Who does "she" refer to?*

3. The policeman arrested the offender after *he* had seen the evidence.
   The policeman arrested the offender after *he* had hidden the evidence.

   Question to the machine: *Who does "he" refer to?*

A collection of 150 Winograd schemas
https://cs.nyu.edu/faculty/davise/papers/WinogradSchemas/WSCollection.html

A DIVISION OF LABOR

We can divide the types of tasks we as humans can do into 3 broad categories:

1. Computational tasks
   - Adding a column of numbers
   - Sorting a list of numbers
   - Managing a payroll
   - Calculating the trajectory of a space shuttle

2. Recognition tasks
   - Recognizing your best friend
   - Understanding the spoken word
   - Finding a tennis ball in the grass

3. Reasoning tasks
   - Planning what to wear today
   - Deciding on your courses for the next semester
   - Running the triage center in a hospital after an emergency

A DIVISION OF LABOR

We can divide the types of tasks we as humans can do into 3 broad categories

1. Computational tasks
   - Typically have algorithmic solutions
   - Computers perform them faster than humans
   - Computers perform them more accurately than humans

2. Recognition tasks
   Example: recognizing an individual's face

3. Reasoning tasks
   Example: planning your major in college

A DIVISION OF LABOR

We can divide the types of tasks we as humans can do into 3 broad categories

1. Computational tasks

2. Recognition tasks : (e.g. recognizing an individual's face)
    - Process massive amounts of sensory information
    - Access massive amounts of past experience
    - Require generalisation of knowledge
    - Humans are often better than computers

3. Reasoning tasks
    Example: planning your major in college

A DIVISION OF LABOR

We can divide the types of tasks we as humans can do into 3 broad categories :

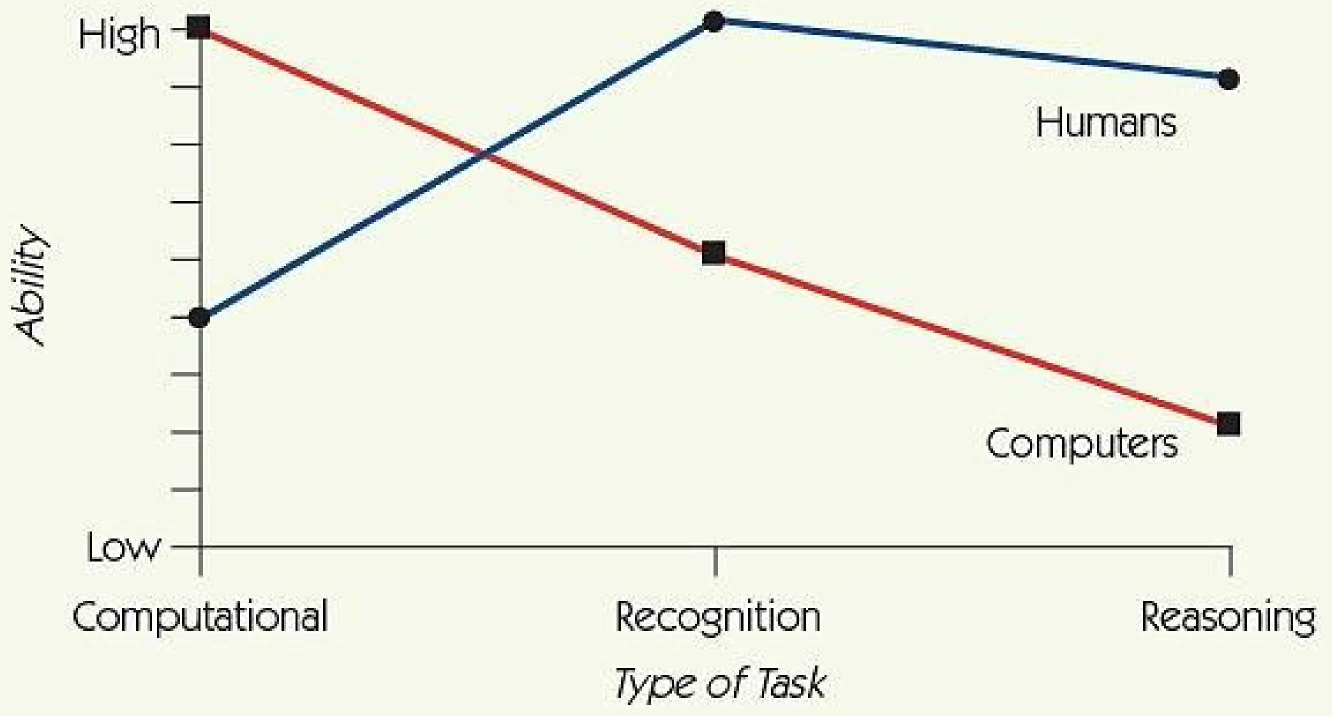
1. Computational tasks

2. Recognition tasks
   Example: recognizing an individual's face

3. Reasoning tasks
   - Reasoning tasks require accessing memory, as well as cause and effect information.
   - **Formal reasoning** can be automated to some extent
     - Problems become intractable quickly
   - **Informal reasoning** or Common-sense reasoning
     - Requires great experience and knowledge

A DIVISION OF LABOR

FIGURE 15.2



Human and computer capabilities

HOW CAN WE REPRESENT KNOWLEDGE FOR THE COMPUTER?

Two common ways of storing knowledge in a computer are *formal languages* and *semantic nets*.

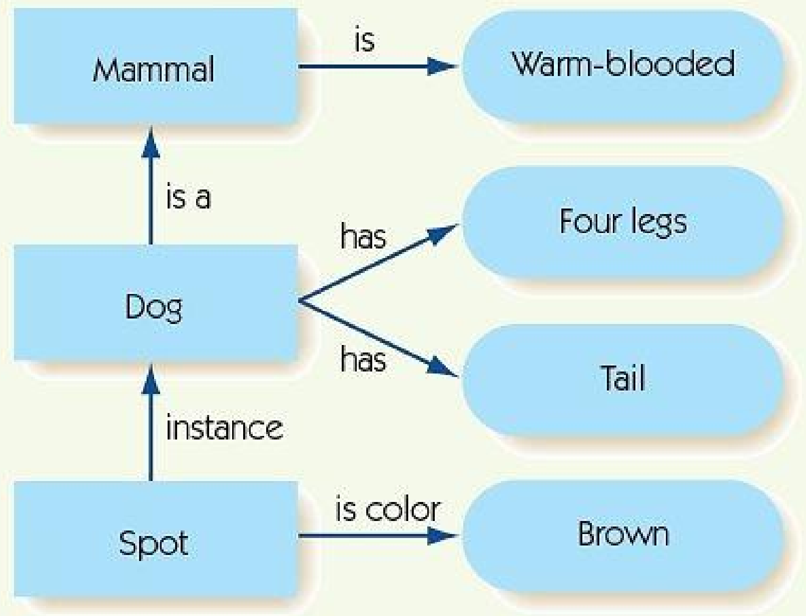
Formal languages are in principle like natural languages, but with a generally much simpler grammar and a lot less potential for ambiguity.

Natural Language Statement	Symbolic Representation
Spot is a dog.	*dog(Spot)*
Spot is brown.	*brown(Spot)*
Every dog has four legs	*(∀x) (dog(x) -> four-legged(x))*
Every dog has a tail	*(∀x) (dog(x) -> tail(x))*
Every dog is a mammal	*(∀x) (dog(x) -> mammal(x))*
Every mammal is warm-blooded	*(∀x) (mammal(x) -> warm-blooded(x))*

KNOWLEDGE REPRESENTATION

- Graphical representation
  - Aka **Semantic net**
    - Nodes for objects or categories of objects
    - Edges for relationships
    - Nodes inherit features through “is-a” relationships

FIGURE 15.3

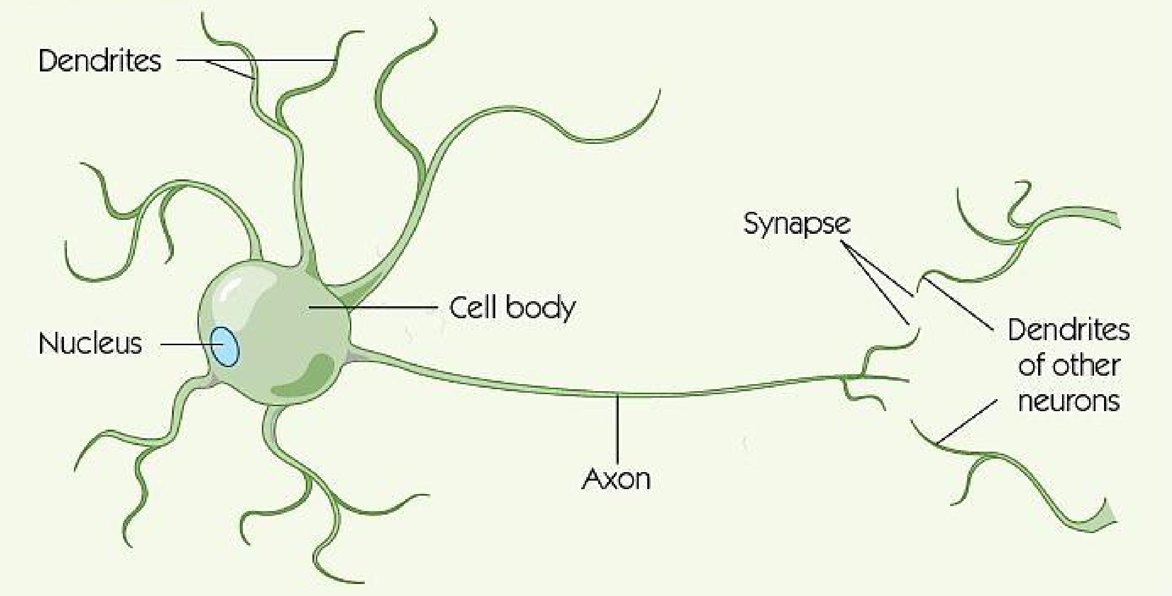


A semantic net representation

MIMICKING A SIMPLIFIED VERSION OF THE BRAIN

To make computers “learn” and “think” like humans, it is natural to mimic the way the human brain functions.
Human brain contains about 86 billion (10^{12}) neurons, which are like very simple computational devices.

FIGURE 15.4



A neuron

ARTIFICIAL NEURAL NETWORK (ANN)

The human brain can be seen as a **connectionist architecture**.

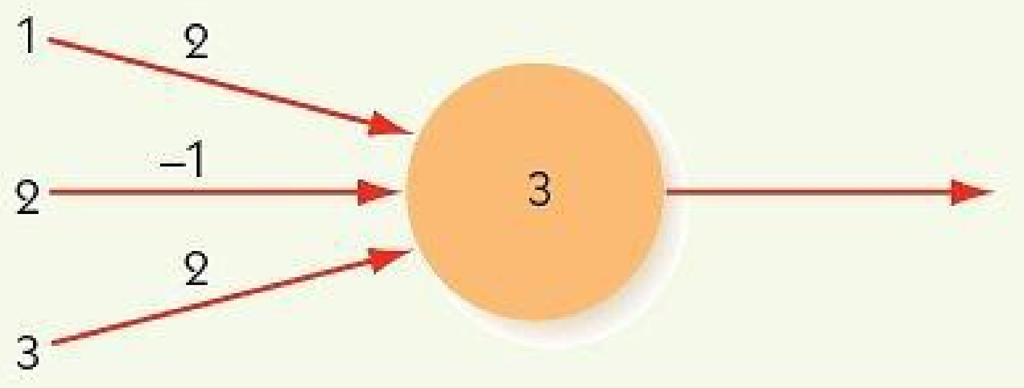
Artificial **neural networks** mimic this approach.

Neural networks are often used in recognition tasks as they can "learn" from training input.

Individual artificial "neurons" have:

- Incoming weighted edges
- An activation level (threshold or more complicated functions)
- Outgoing weighted edge

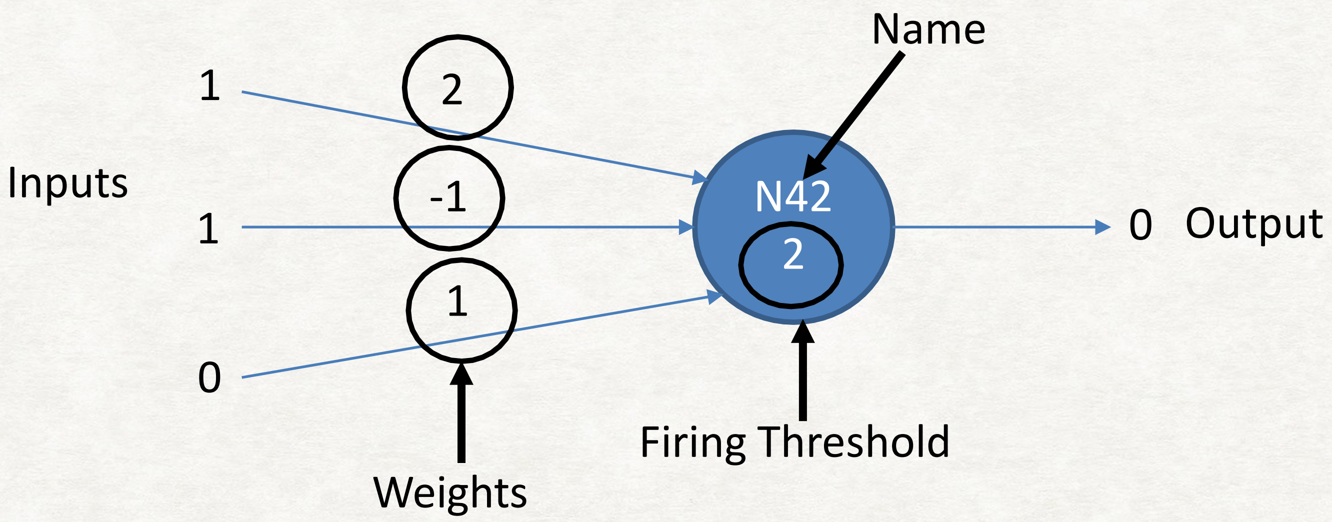
FIGURE 15.5



One neuron with three inputs

https://becominghuman.ai/has-computationalism-failed-7e449287e6dc
https://en.wikipedia.org/wiki/Connectionism#Connectionism_vs._computationalism_debate

ARTIFICIAL NEURONS



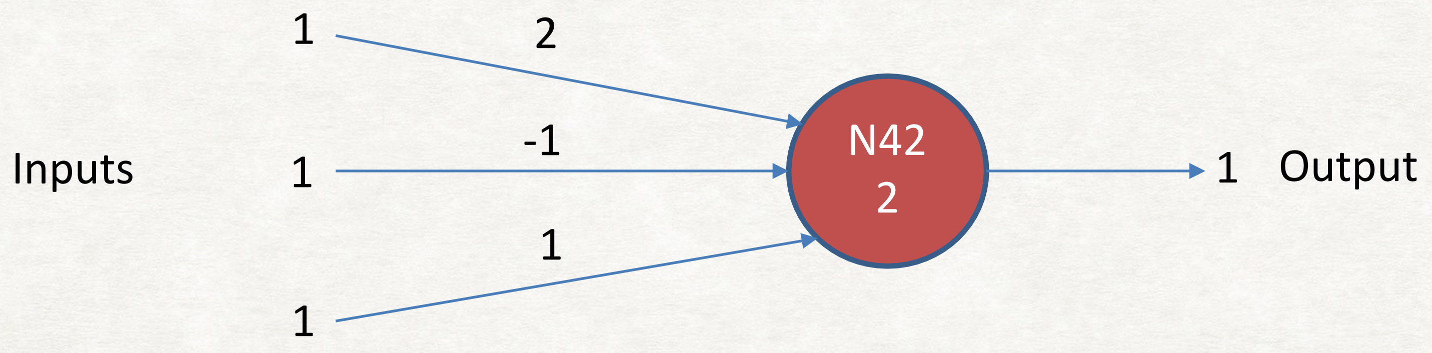
Each input is fed an *input value* 0 or 1.

This value is multiplied with the weight and the results are added over all inputs to the neuron.

Here: 1 * 2 + 1 * (-1) + 0 * 1 = 1

If the result reaches the firing threshold, then the neuron fires. Here it doesn't.

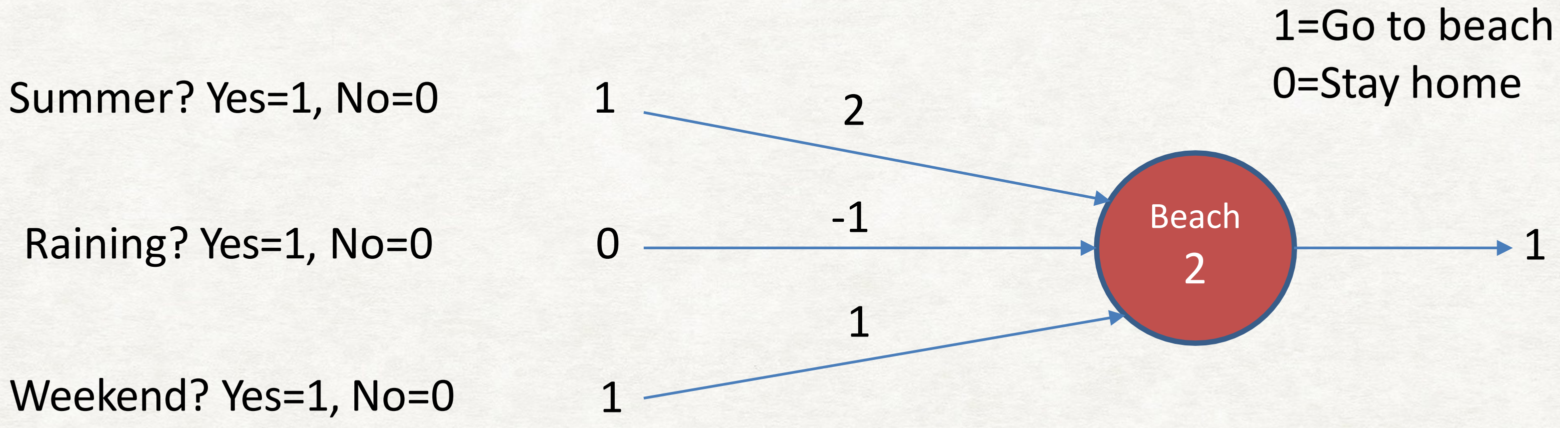
ARTIFICIAL NEURONS



Here, our last input has changed: 1 * 2 + 1 * (-1) + 1 * 1 = 2

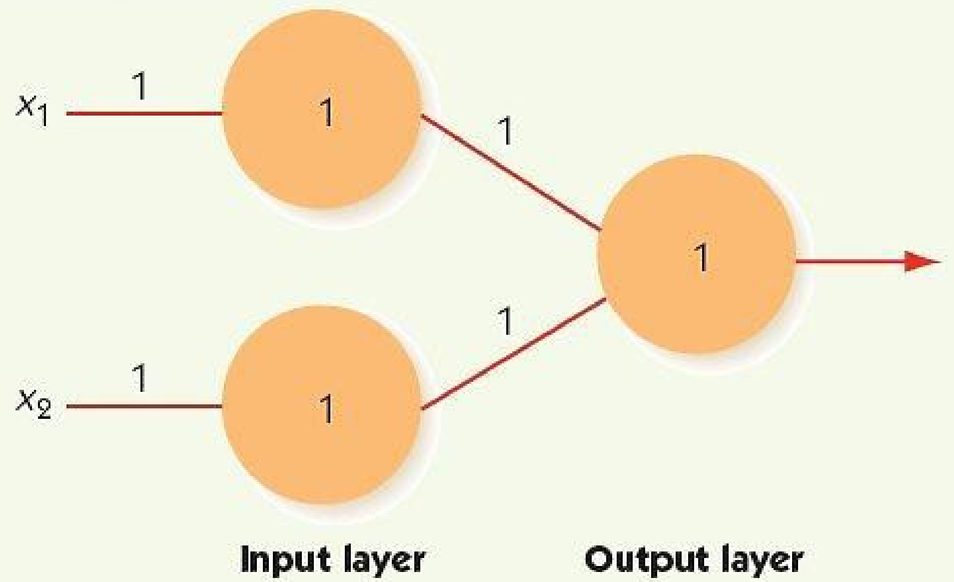
Now the neuron fires.

NEURON DECISION-MAKING EXAMPLE



ARTIFICIAL NEURAL NETWORK (ANN)

FIGURE 15.7



A simple neural network—OR gate

x1	**x2**	**Output**
0	0	0
0	1	1
1	0	1
1	1	1

ARTIFICIAL NEURAL NETWORK (ANN)

Networks with only one input and output layers:

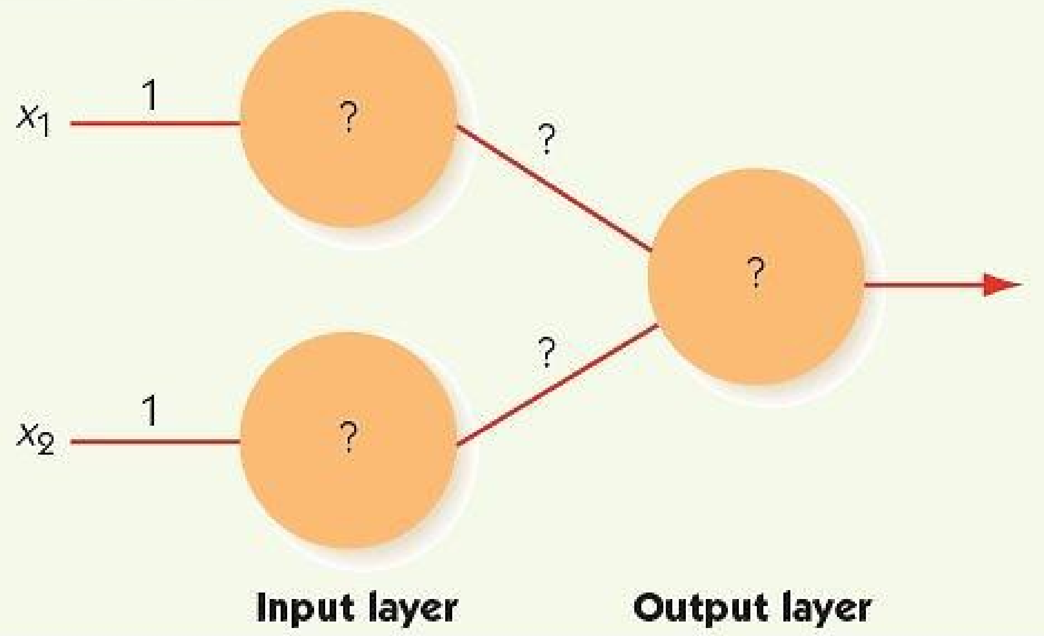
- Can solve many problems, but not all
- For, example consider the XOR operation

FIGURE 15.8

Inputs X_1	Inputs X_2	Output
0	0	0
1	0	1
0	1	1
1	1	0

The truth table for XOR

FIGURE 15.9



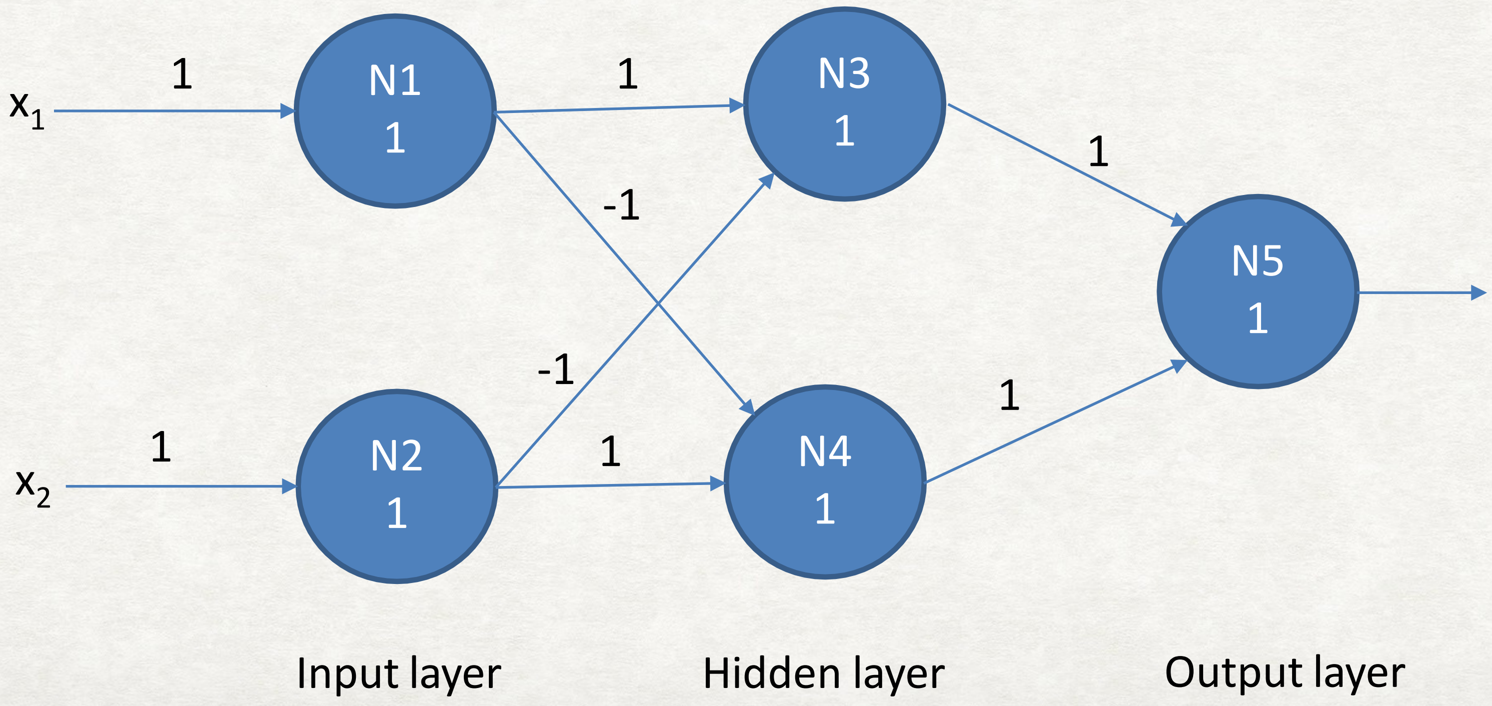
An attempt at an XOR network

HIDDEN LAYER IN NEURAL NETWORKS

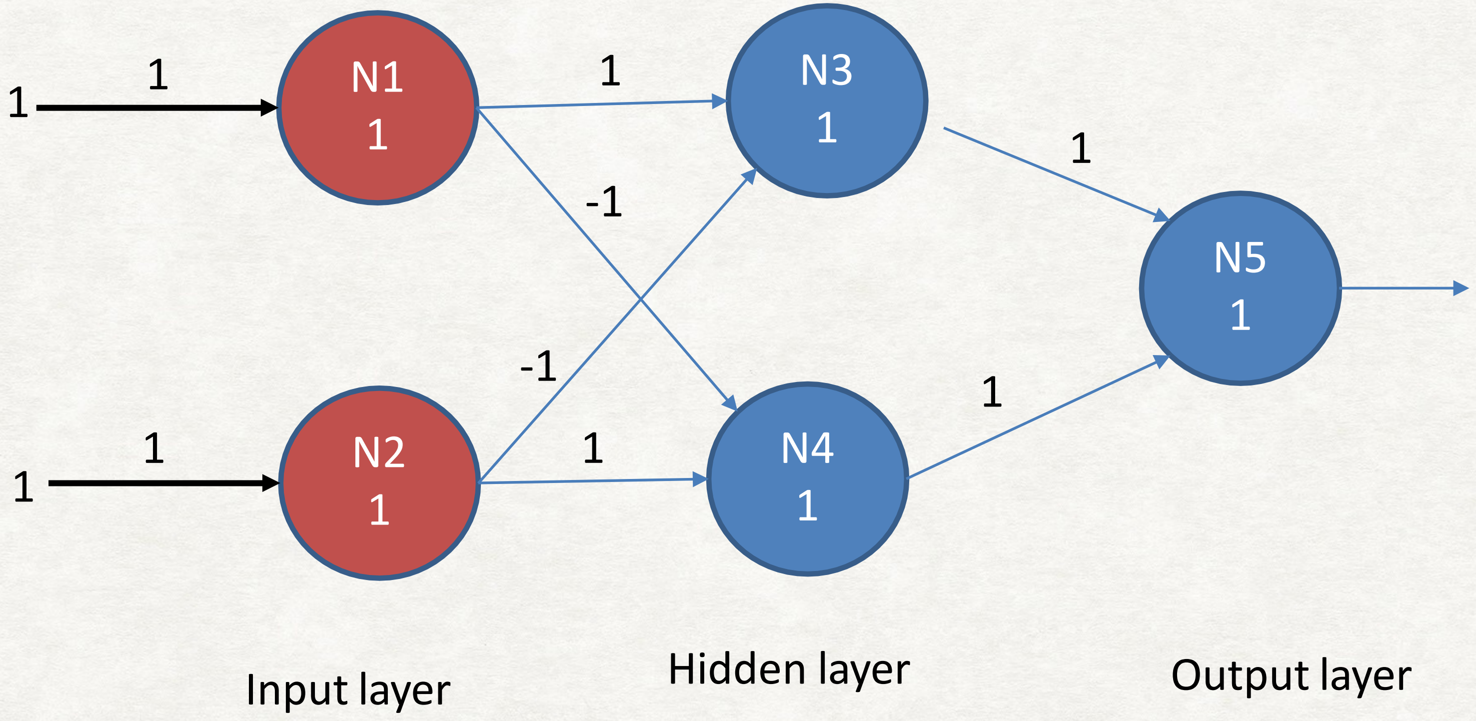
Add an intermediate layer between input and output

- Hidden layer

Can solve most problems given the right weights and the number of neurons in the hidden layer.

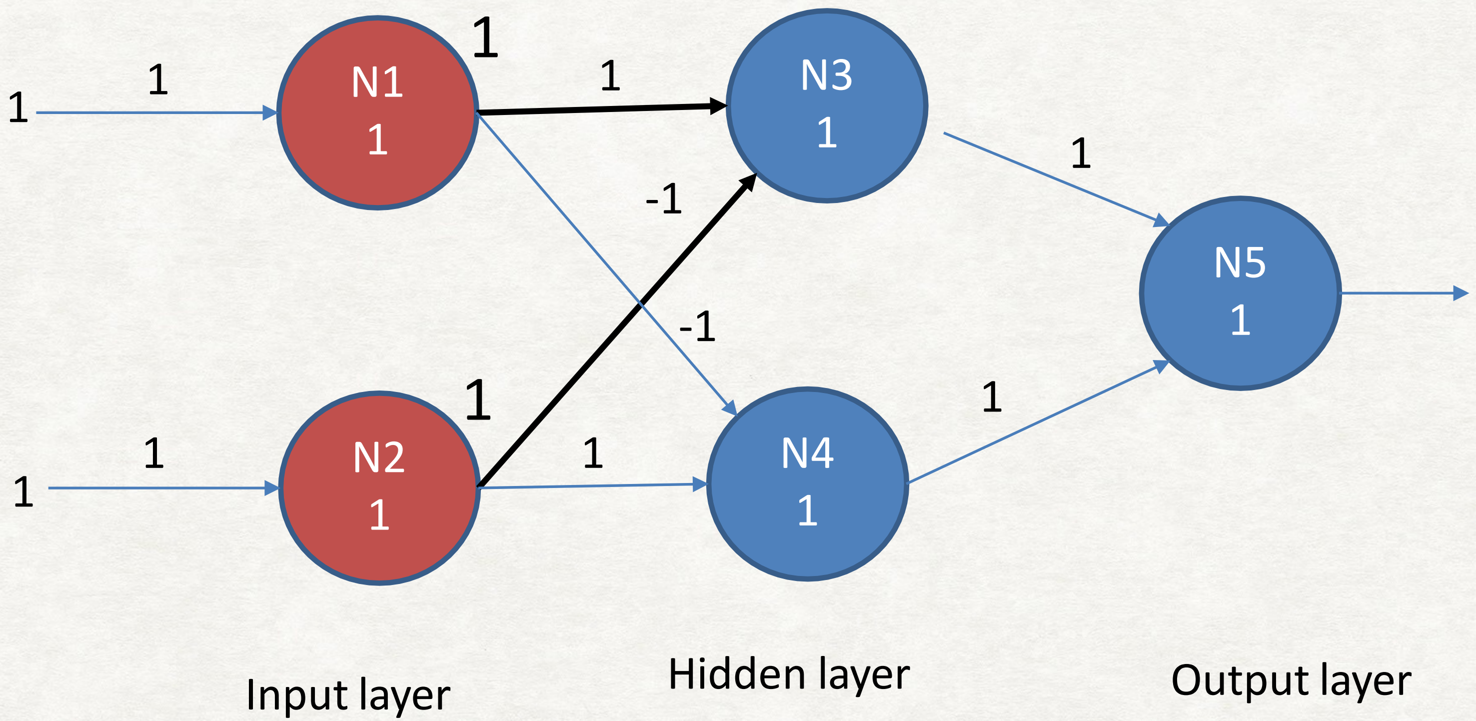


HIDDEN LAYER IN NEURAL NETWORKS



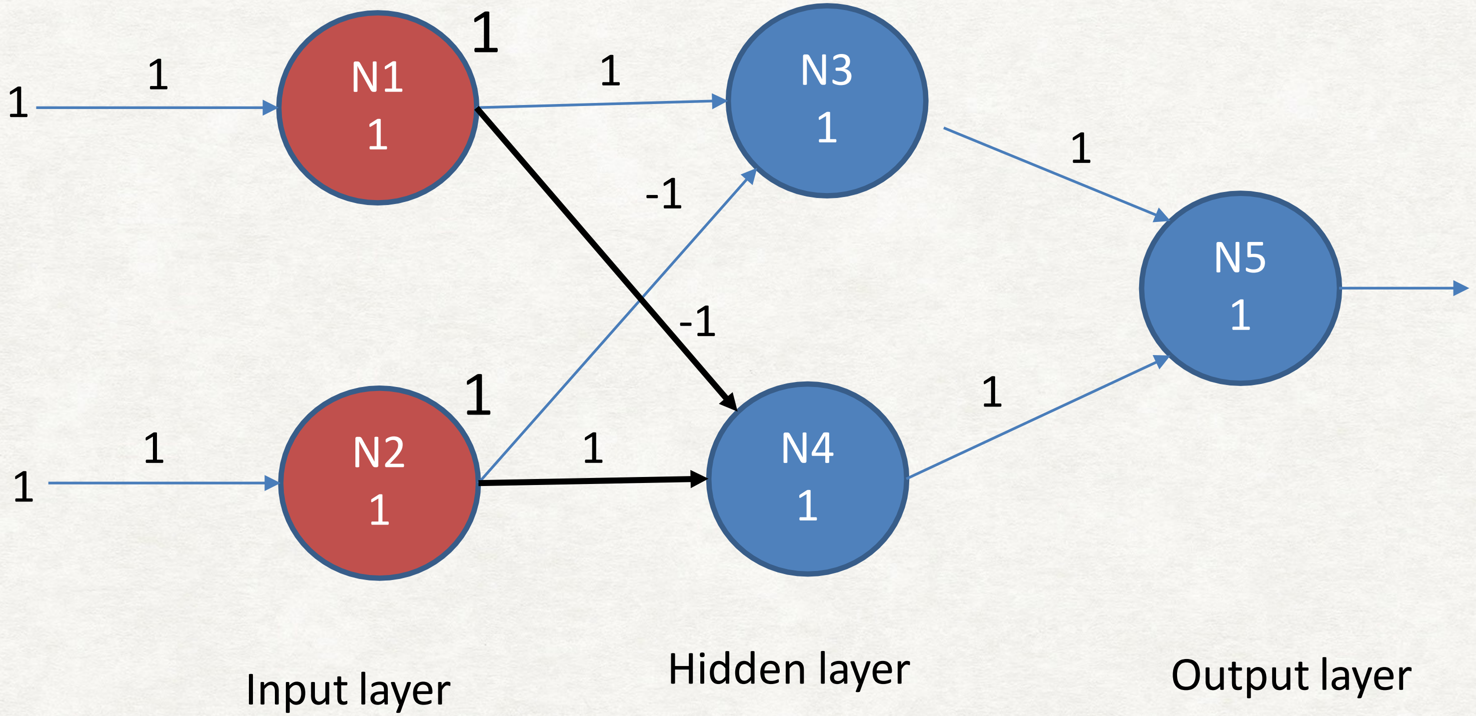
Neurons N1 and N2 will fire.

HIDDEN LAYER IN NEURAL NETWORKS



Neurons N3 will not fire.
Input N3 = 1+(-1) = 0 < 1(threshold of the neuron)

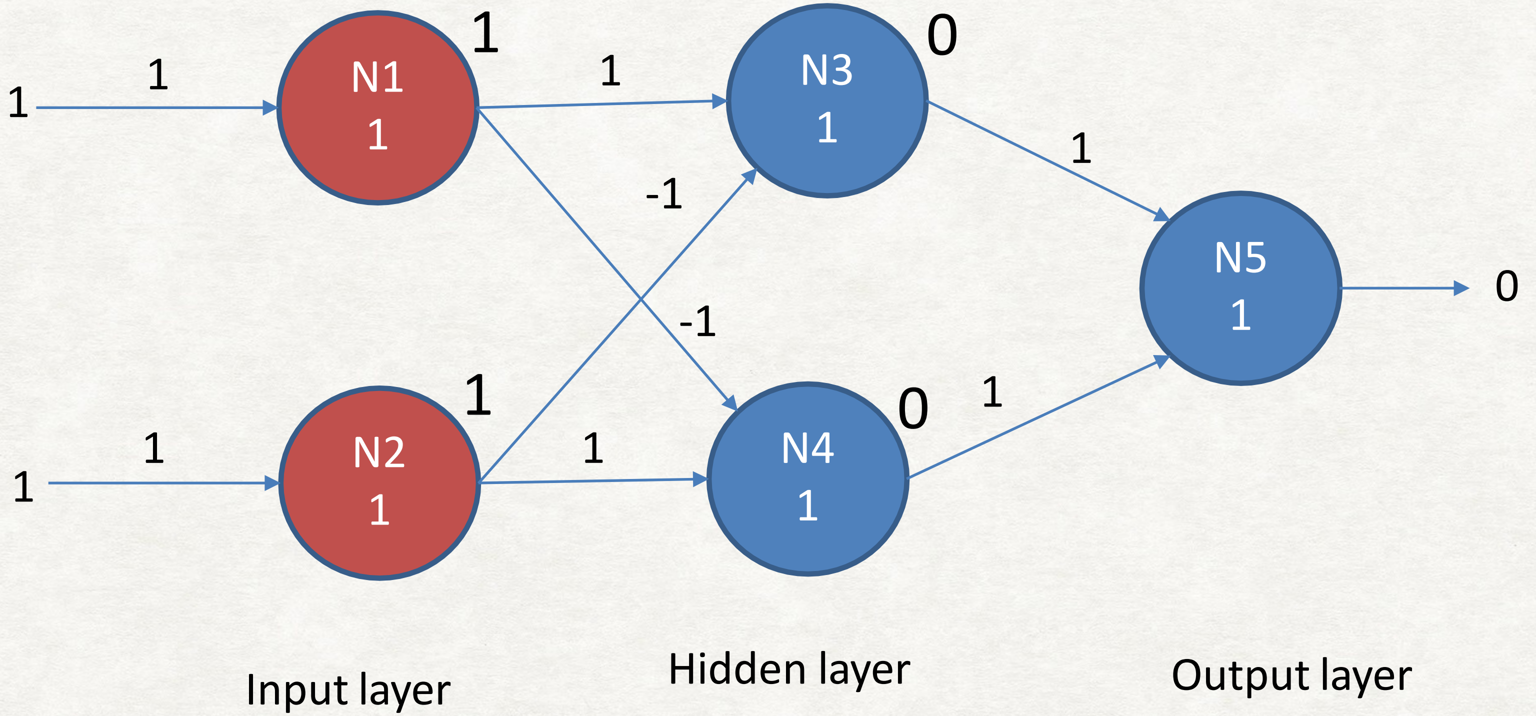
Hidden Layer in Neural Networks



Neurons N4 will not fire.

Input to N4 = 1+(-1) = 0 < 1(threshold of the neuron)

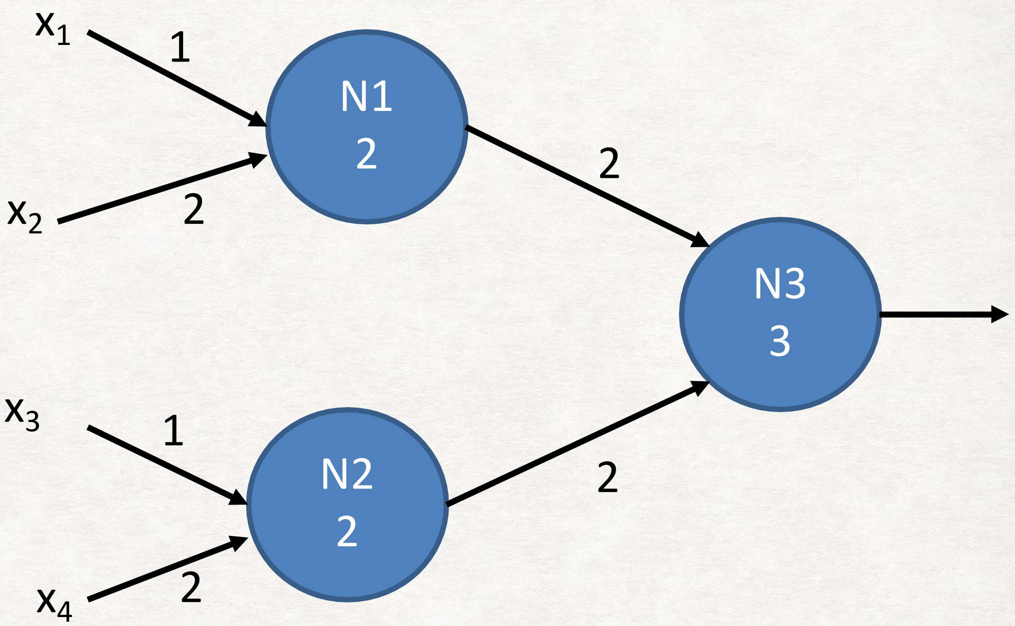
Hidden Layer in Neural Networks



Input to neuron N5 = 0*1+(0 *1) = 0 < 1(threshold of the neuron)
Neuron N5 will not fire.
Output will be 0, as needed. ($1 \oplus 1 = 0$)

LET'S DO AN EXERCISE.

In the given neural network, which combinations of input values cause node N3 to fire?



For N3 to fire, weighted input must be ≥ 3.
N1 must fire **and** N2 must fire.

For N1 to fire, weighted input must be ≥ 2.
Either x_2 must be 1 or both x_1 and x_2 must be 1
$< x_1, x_2> =$ <1,1> or <0,1>

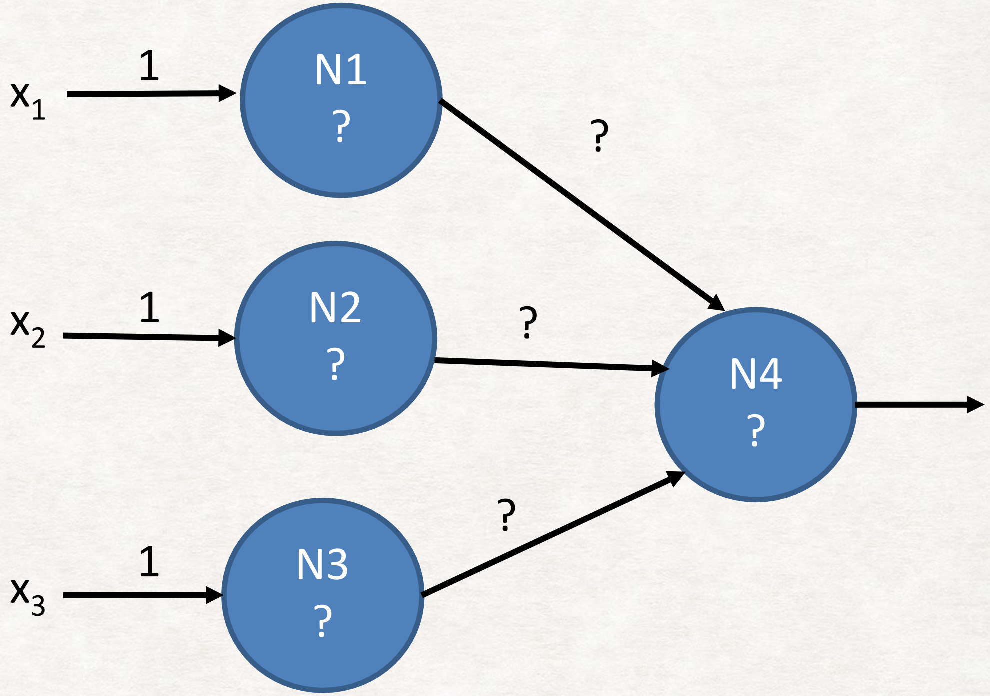
For N2 to fire, weighted input must be ≥ 2.
Either x_4 must be 1 or both x_3 and x_4 must be 1
$< x_3, x_4> =$ <1,1> or <0,1>

Therefore, for N3 to fire,
the possible combinations of $<x_1, x_2, x_3, x_4>$ can be:
<1,1,1,1> , <1,1,0,1>, <0,1,1,1>, <0,1,0,1>

LET'S TRY ANOTHER EXERCISE!

Assign weights and threshold values in the given neural network so that the output neuron fires only when x_1 and x_3 have the value 1 and x_2 has the value 0.

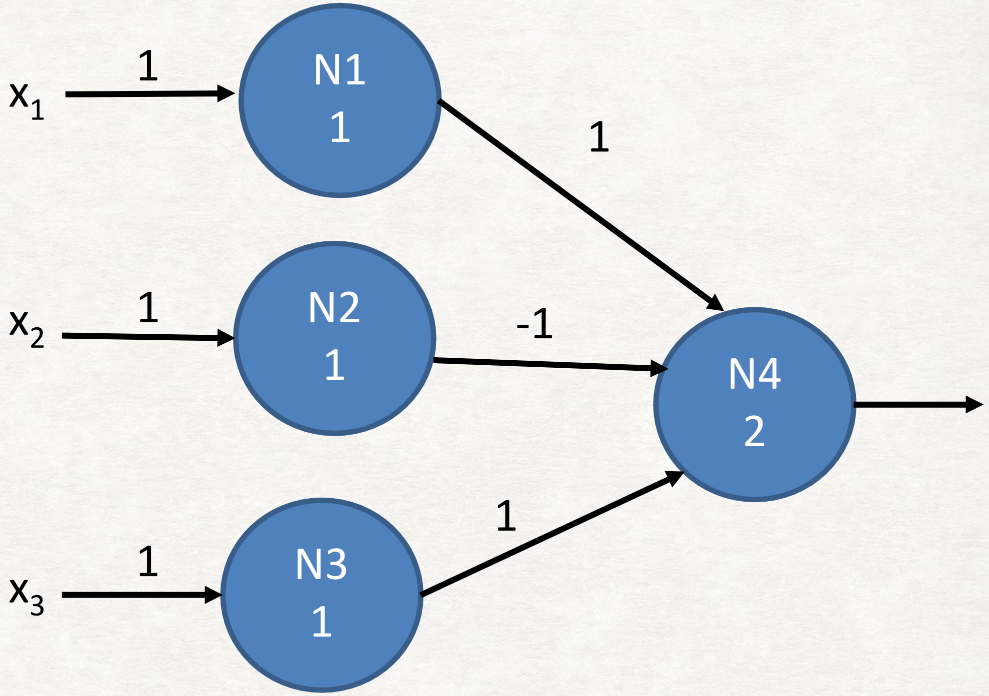
Remember that weights can be negative.



SOLUTION - ANOTHER EXERCISE!

Assign weights and threshold values in the given neural network so that the output neuron fires only when x_1 and x_3 have the value 1 and x_2 has the value 0.

Remember that weights can be negative.



TO SUMMARIZE

Whether a neuron fires or not is a function of:

- The input values
- The weights on the inputs
- The firing threshold

Insight: Neurons with large weights on many inputs and a low firing threshold are more likely to fire than neurons with small or negative weights and a high firing threshold.

A weight of 0 for an input means that this input is effectively unused.